THE SCATTERING OF HIGH ENERGY NEUTRONS BY PROTONS

BY

JOHN SETH LAUGHLIN

A.B., Willamette University, 1940
M.S., Haverford College, 1942

AN ABSTRACT OF A THESIS

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
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ACKNOWLEDGMENT

I wish to thank Professor P. G. Kruger, who suggested and directed this research, for his advice and assistance.

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The angular distribution of the recoil protons in the neutron proton scattering process has been investigated in a high pressure (25 atmospheres) cloud chamber. The recoil protons were produced in methane gas by a well collimated homogeneous beam of neutrons one half inch in diameter taken in the forward direction from the D (d,n) He^3 reaction. A thin (.5 mev) deuterium gas target was employed and a magnetic field deflected the deuteron beam from the forward direction after passing through the target. This prevented neutrons from sources other than the deuterium target from entering the cloud chamber. The neutron spectrum of this arrangement was examined with the cloud chamber and showed a strong peake between 12.0 mev and 13.0 mev superimposed on a low intensity continuous spectrum originating from the thin foil windows on the entrance and exit of the target. The intensity of neutrons between 11.0 mev and 12.0 mev was less than 20% of the intensity between 12.0 mev and 13.0 mev.

Approximately 1900 recoil protons satisfied selection criteria and have been measured. Of these 1563 were produced by neutrons between 12.0 mev and 13.0 mev energy. The data are given in Table 1.

The azimuthal correction factors used were determined from the experimental data and are in good agreement with the correction factors calculated from the geometry and illuminated height of the chamber. For the scattering angle intervals indicated in Table 1 the data were plotted in 20° azimuthal angular intervals. The number of recoil protons scattered into those azimuthal angle intervals in which all tracks were fully illumniated determined the number which would have been measured if all the tracks in all the azimuthal angle intervals could have been measured. The ratio of this

number to the actual observed number yielded the azimuthal correction factors.

Since the neutron beam was collimated, all recoil protons originated from a one-half inch diameter cylinder through the center of the chamber. Knowledge of the light beam height permitted a straightforward calculation of the expected azimuthal distribution and correction factor for tracks of a given length in each scattering angle interval. The shape of these calculated azimuthal distributions was in good agreement with the experimental distributions.

A length correction factor is necessary since for each different scattering angle interval the recoil protons have different energies and lengths. Since these lengths and the chamber geometry were well known these factors could be calculatd from simple geometrical considerations.

A measure of statistical uncertainty for each scattering angle interval was calculated on the basis of the probable error in the total number of tracks in each interval, the probable error in the determination of the azimuthal correction factor, and the probable error in the conformity of the data to the length correction factor. The resultant probable errors are given in Table 1.

A ratio of the differential cross sections for neutron scattering in the backward direction to scattering in the perpendicular direction in the center of mass system of either unity (spherically symmetric scattering) or slightly greater than unity can be consistent with these data. This possible small asymmetry is in the opposite direction to that found by Amaldi (1) and co-workers and by Champion and Powell (2). Later results by Powell (3) apparently show spherically symmetric scattering.

(1) E. Amaldi, D. Bocciarelli, B. Ferretti, and G. C. Trabacchi, *Naturwissenschaften*, **30**, 582 (1942).

(2) F. C. Champion and C. F. Powell, *Proc. Roy. Soc. London,* **A183,** 64 (1944).

(3) Footnote 38, G. Wentzel, *Reviews of Modern Physics* **19,** 10 (1947).

TABLE 1

Experimental Data for Recoil Protons Produced by High Energy Neutrons

Scattering angle interval in center of mass system	No. of recoil protons	Azimuthal correction factor	Length correction factor	No. of corected tracks	Interval solid angle	No. of recoil protons per unit solid angle in indicated scattering angle interval	Relative no. of recoil protons per unit solid angle in indicated scattering angle interval
0-21	94	1.135	2.78	296.5	.415	714	1.24 ± .17
11-31	127	1.57	2.54	506	.786	645	1.12 ± .14
21-41	171	1.94	2.32	770	1.125	685	1.19 ± .13
31-51	236	2.16	2.08	1060	1.431	740	1.285 ± .12
41-61	273	2.26	1.82	1122	1.698	660	1.145 ± .09
51-71	341	2.20	1.62	1216	1.903	638	1.105 ± .08
61-81	433	2.07	1.39	1247	2.063	605	1.05 ± .07
71-91	523	1.94	1.28	1299	2.160	601	1.04 ± .06
81-101	592	1.80	1.18	1259	2,180	576	1.00 ± .06

VITA

John Seth Laughlin was born in Canton, Missouri, January 26, 1918. He received his elementary education in the public schools of Salem, Oregon. In 1940 he received the A. B. degree from Willamette University, and in 1942 the M. S. degree from Haverford College. From 1940 to 1942 he was a teaching assistant at Haverford College, and from 1942 to 1944 a teaching assistant at the University of Illinois. From 1944 through 1945 he was a research associate on O. S. R. D. projects OEMsr-102 and OEMsr-241. From 1945 to 1946 he was a half-time research assistant, and from 1946 to 1947 a research assistant professor.

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